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(54) **Battery-powered computing apparatus including a battery charge level indicating arrangement.**

(57) A battery charge level monitor (102, 103) is provided for a computing system (100). The monitor (102, 103) stores a value representing the charge stored in a battery (106). This value is varied to take into account battery charge depletion resulting from operations by the computing system (100), and to take into account charge added to the battery by a recharger (201). An operator can access the value via a display (103) using computer commands or by automatic display of the value by the computing system (100).

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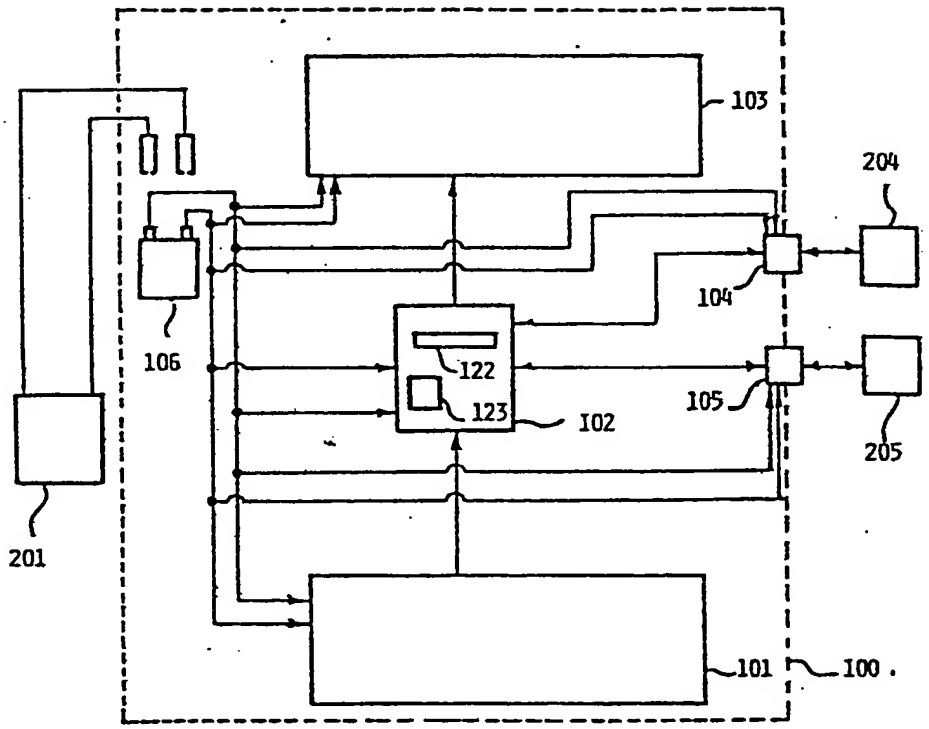

FIG 1

BATTERY-POWERED COMPUTING APPARATUS INCLUDING A BATTERY CHARGE LEVEL INDICATING ARRANGEMENT

The present invention relates to battery-powered computing apparatus including a battery charge level indicating arrangement.

As is well known, many computing systems such as portable calculators and portable computers require an internal battery in order to operate independently from AC lines. The eventual discharge of the internal battery can cause problems for a computer system operator if sufficient warning of power loss is not given.

Traditionally, battery-powered computer systems have only provided the user with a low battery indicator which directly monitors the battery voltage and informs the user when the voltage level of the battery falls below a predetermined value. This provides a warning to the user of imminent power loss, but does not allow for longer range anticipation of power loss.

Another method for monitoring battery discharge is for the user to set a timer immediately upon charging the battery. By referring to the timer the user can determine how long the computing system has been running since the battery was last recharged. This method unfortunately has many drawbacks not the least of which is that no account is taken of the differing effects on battery charge level of different types of operation in which the computing system may be involved.

It is an object of the present invention to provide a battery charge level indicator which can provide the operator of the computing system with a more accurate indication of the state of the battery.

In accordance with the present invention, this object is achieved by the provision of battery-powered computing apparatus including a battery charge level indicating arrangement characterized in that said arrangement comprises calculating means for computing a value related to the level of charge of the battery, the calculating means being operative to distinguish between predetermined operations involving the apparatus and being arranged, in computing said value, to take into account the respective effect on battery charge level of each said operation actually undertaken by the apparatus, and display means for displaying said value or a quantity dependent thereon.

Since the value computed by the battery charge level indicating arrangement reflects the differing effect on battery charge state of different operations performed by the computing apparatus, the indication of battery charge level provided by the computed value is more accurate than that achievable by a simple timer. Furthermore, where one of said predetermined operations is a recharging operation, the problem of having to reset the value whenever the battery is recharged is avoided as is the problem of deciding a reset point where the battery is only partially recharged (both these problems are, of course, inherent in the aforementioned timers).

The number of operations distinguished by the calculating means depends on the required refinement of the arrangement. Advantageously, the predetermined operations include a dormant operation, a wait operation, a computing operation, one or more interface operations (for example, RS232 interface, modem link) and a recharging operation.

In a preferred embodiment of the indicating arrangement, the calculating means includes a memory for storing said value, the calculating means being arranged at intervals to compute an updated value by adjusting the stored value by an amount corresponding to the change in

battery charge caused since the last update as a result of the current said operation or operations involving the apparatus. Advantageously, during each update, an adjustment to said stored value is made for each said operation that is current, each said adjustment having a magnitude dependent on the battery current caused by the corresponding operation and on the time interval since the last update.

It will be appreciated that the computing apparatus may either be one intended to be powered only by a battery or one which has the additional capability of being mains powered; in this latter case, the calculating means is, of course, arranged to distinguish between battery and mains operation of the apparatus.

The said value computed by the calculating means may be a direct measure of the battery charge state (for example, percentage charge remaining) or some other related measure (such as remaining life based on a projected average charge depletion rate). Furthermore, the display means may display said value direct or else a related quantity, such as an analog representative of said value (the value computed by the calculating means will generally be numeric although this may not always be the case as the calculating means could in theory be of analog form).

There now follows a detailed description which is to be read with reference to the accompanying drawings of a computing system provided with a battery-charge level indicating arrangement; it is to be understood that the computing system and indicating arrangement has been selected for description to illustrate the invention by way of example and not by way of limitation.

In the drawings:

Figure 1 is a block diagram of the computing system including the battery charge level indicating arrangement;

Figure 2 is a flowchart illustrating the operation of the battery charge level indicating arrangement.

In Figure 1, a microcomputer 102 within a computing system 100 calculates the charge within a battery 106. The value (FUEL) representing the current charge within battery 106 is stored by the microcomputer 102 within a memory register 122. The value FUEL in the register 122 is continually updated to accurately represent the current charge within the battery 102.

For instance, in the preferred embodiment, every 128 milliseconds (ms) the microcomputer 102 runs a monitor program 123 -- a flowchart of the monitor program is shown in Figure 2. The monitor program 123 first subtracts from FUEL a value representing the minimum amount of charge consumed by computing system 100. This minimum charge may be calculated by multiplying the current used by computing system 100 when it is inactive (SLEEP) times 128 ms. In the flowchart of Figure 2, the operation of depleting FUEL by said minimum charge is represented by the operation FUEL=FUEL-SLEEP CURRENT.

The monitor program 123 then takes into account the amount of additional charge consumed by the computing system 100 for its other activities. A value representing this additional charge is subtracted from FUEL. If computing system 100 is active but in a wait mode, the additional charge is calculated based on the current (WAIT CURRENT) used by computing system 100 in wait mode. If computing system is performing an operation, the additional charge is calculated based on the current (RUN CURRENT) used by computing system 100 to perform the operation.

The monitor program 123 also may take into account the amount of charge consumed by the computing system 100 in interfacing with other computing systems. For instance, if a modem interface 104 is interacting with a modem 204, the monitor program 123 subtracts from FUEL a value representing an amount of charge based on the current (MODEM CURRENT) used by this interaction. If a RS232 cable interface 105 is

interacting with another computing system 205, the monitor program 123 subtracts from FUEL a value representing an amount of charge based on the current (RS232 CURRENT) used by this interaction.

Since the battery 106 cannot store a negative charge, the monitor program 123 will not store a value of FUEL less than 0. Additionally, if a charger 201 is charging battery 106, the monitor program will add to FUEL a value based on the average current (CHARGE CURRENT) the battery 106 draws when it is charging. Finally, if the battery is fully charged (FUEL = 100%), additional charging will not result in additional charge being stored in the battery 106, so the monitor program 123 will not allow the value of FUEL to be over 100%.

An operator may obtain the current value of FUEL by entering an appropriate command on a keyboard 101. The current value of FUEL may then be presented on a display 103. Additionally, if desired, the computing system 100 may present the current value of FUEL as the end of each command given by the operator to the computing system.

Initial determination of when the battery 106 is fully charged (FUEL = 100%) can be utilized throughout the life of the battery 106, or can be adjusted by the microcomputer 100 to compensate for performance degradation resulting from ageing of the battery 106.

From the foregoing, it can be seen that the battery charge level indicating arrangement described and illustrated above serves to compute and store a value which represents the amount of charge within the battery of the computing system. The charge value is varied to take into account the amount of charge consumed by computer operations, and the amount of charge replenished by a battery recharger. The charge value is readily accessible by a computer operator, thus providing him with accurate information concerning the charge within the battery and allowing the operator to more accurately estimate the amount of operations which may be done before power loss occurs.

CLAIMS

1. Battery-powered computing apparatus (100) including a battery charge level indicating arrangement characterized in that said arrangement comprises:

calculating means (102) for computing a value (FUEL) related to the level of charge of the battery (106), the calculating means (102) being operative to distinguish between predetermined operations involving the apparatus (100) and being arranged, in computing said value (FUEL), to take into account the respective effect on battery charge level of each said operation actually undertaken by the apparatus (100), and

display means (103) for displaying said value (FUEL) or a quantity dependent thereon.

2. Computing apparatus according to claim 1, wherein the calculating means (102) includes a memory (102) for storing said value (FUEL), the calculating means (102) being arranged at intervals to compute an updated value by adjusting the stored value (FUEL) by an amount corresponding to the change in battery charge caused since the last updated as a result of the current said operation or operations involving the apparatus (100).

3. Computing apparatus according to claim 2, wherein during each update, an adjustment to said stored value (FUEL) is made for each said operation that is current, each said adjustment having a magnitude dependent on the battery current caused by the corresponding operation and on the time interval since the last update.

4. Computing apparatus according to claim 2 or claim 3, wherein the said predetermined operations include one or more first operations that result in a reduction in the battery charge, and a second, battery-recharging operation, the calculating means (102) being arranged to adjust said value (FUEL) in one direction when taking account of the or each first operation undertaken by the apparatus (100), and in the opposite direction when taking account of a said second operation.

5. Computing apparatus according to any one of the preceding claims, wherein the said predetermined operations include a computing operation.

6. Computing apparatus according to any one of the preceding claims wherein the said predetermined operations include a non-computing operation.

7. Computing apparatus according to claim 6, wherein said non-computing operation is an operation that increases the charge in the battery.

8. Computing apparatus according to claim 6, wherein said non-computing operation is an operation that interfaces the apparatus (100) with another system.

9. Computing apparatus according to any one of the preceding claims, wherein the calculating means (102), in determing said value, is arranged to take into account changes in the performance of the battery (106) due to ageing.

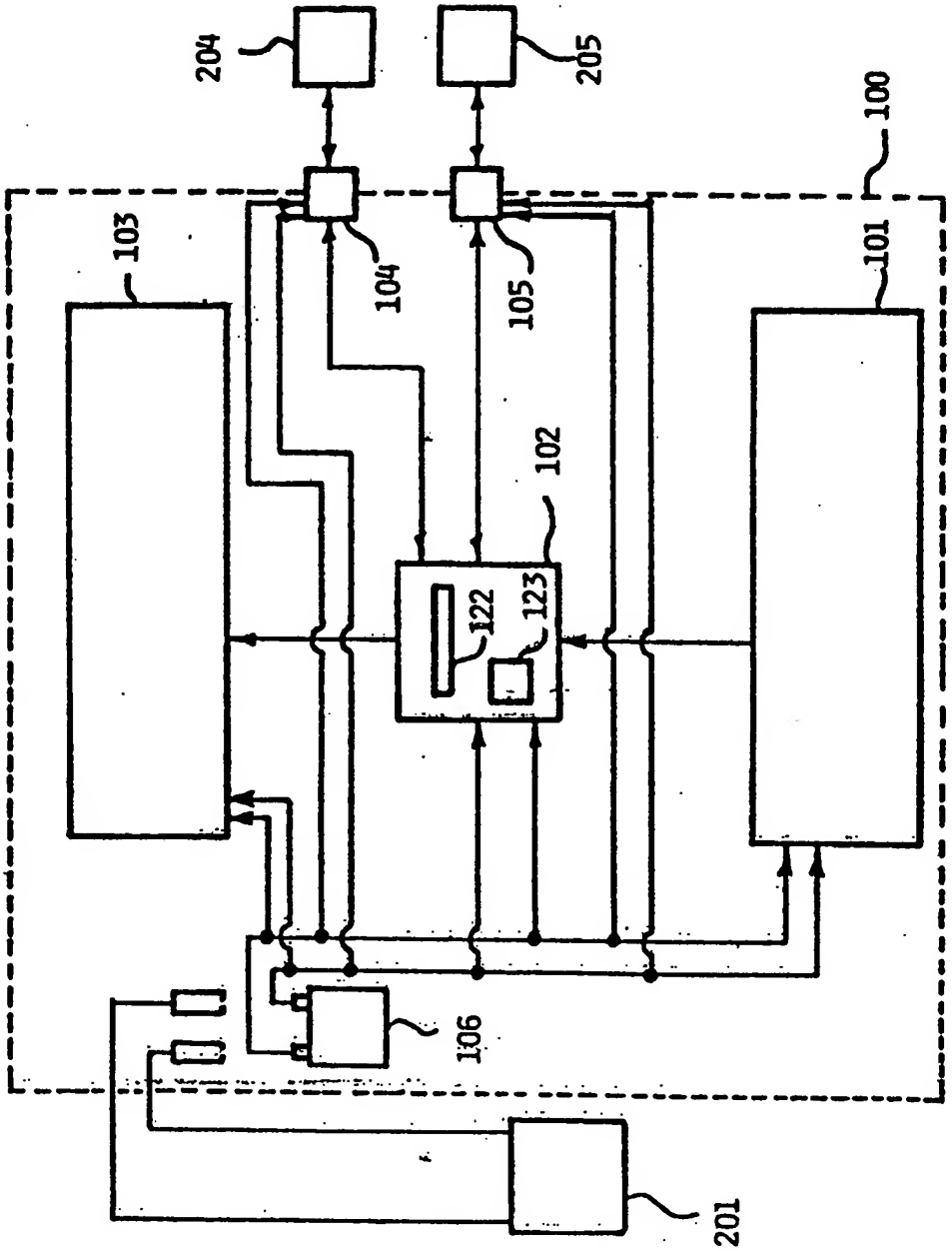

FIG 1

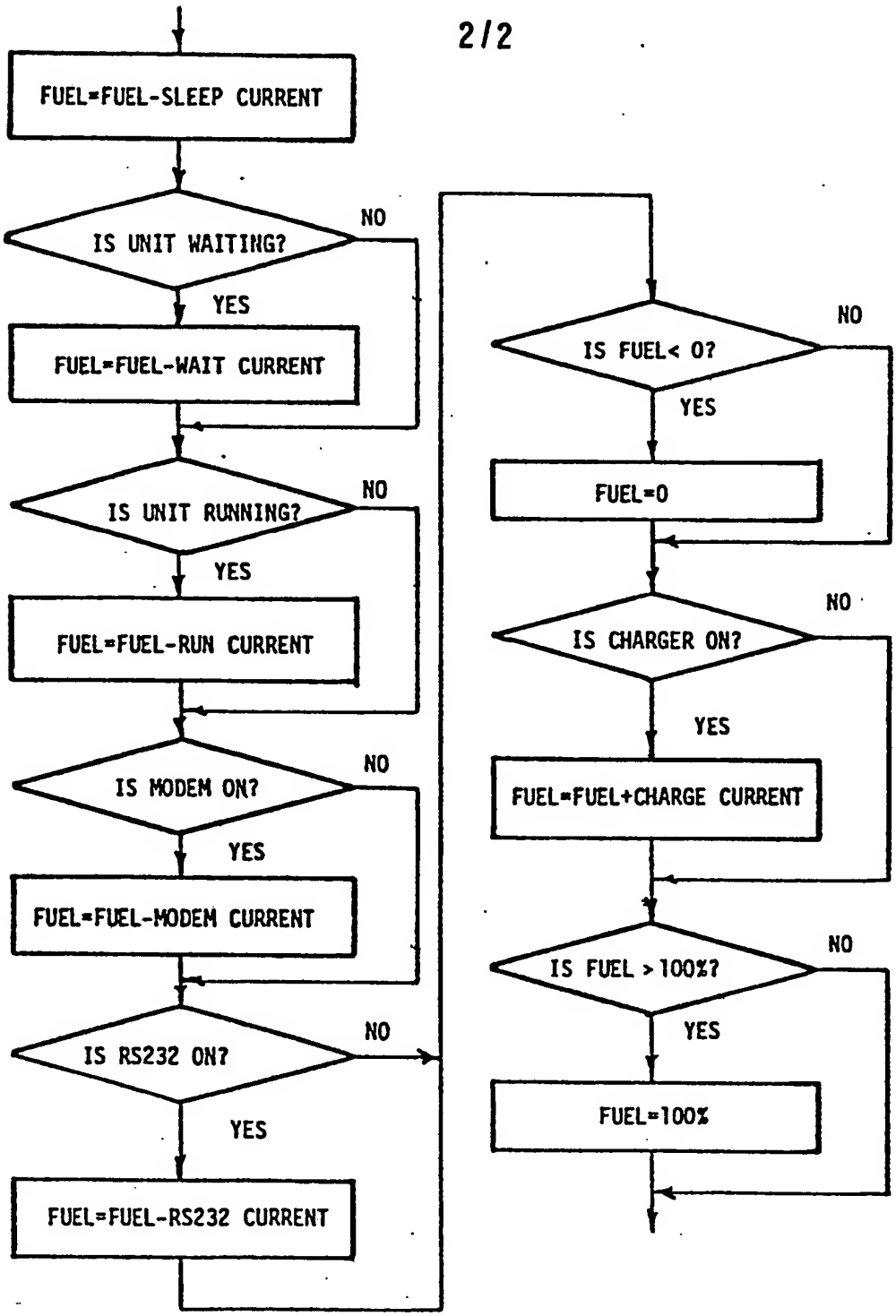
FUEL=FUEL-SLEEP CURRENT
IS UNIT WAITING?
NO
YES
FUEL=FUEL-WAIT CURRENT
IS UNIT RUNNING?
NO
YES
FUEL=FUEL-RUN CURRENT
IS MODEM ON?
NO
YES
FUEL=FUEL-MODEM CURRENT
IS RS232 ON?
NO
YES
FUEL=FUEL-RS232 CURRENT
IS FUEL< 0?
NO
YES
FUEL=0
IS CHARGER ON?
NO
YES
FUEL=FUEL+CHARGE CURRENT
IS FUEL > 100%?
NO
YES
FUEL=100%

FIG 2

European Patent Office

EUROPEAN SEARCH REPORT

0164890
Application number

EP 85 30 3246

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
P,X	US-A-4 455 523 (S.E. KOENCK) * Column 1, lines 24-41, 49-68; column 2, lines 1-2, 60-68; column 4, line 45 - column 6, line 49; figures 1,5 *	1-5,9	G 01 R 31/36 H 02 J 7/10 G 06 F 1/00
P,X	CH-A- 648 936 (H. KÖCHLER) * Page 3, left-hand column, line 21 - right-hand clumn, line 60; figure 1 *	1-5,9	
A	US-A-4 387 334 (R.K. LOPER) * Column 1, lines 39-49, 61-68; column 2, lines 1-8 *	1	
A	EP-A-0 074 444 (J.H. LEMELSON)		
A	FUNKSCHAU, vol. 45, no. 6, 16th March 1973, pages 204-206; D. RÖSNER: "Batterie-Anzeige für Taschenrechner"		TECHNICAL FIELDS SEARCHED (Int. Cl.4) G 01 R G 06 F H 02 J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	19-08-1985	KUSCHBERT D.E.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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